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A CORRELATION OF LOADINGS AND AFTERBODY LENGTH-BEAM RATIOS OF VARIOUS FLYING-BOAT HULLS

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SUMMARY

The gross weight, beam, and afterbody length of 12 contemporary flying boats and amphibians with pointed afterbodies are tabulated and correlated. For most of the hulls considered, the afterbody length-beam ratios are shown to be directly proportional to the gross-load coefficients.

INTRODUCTION

The length-beam ratio of the hull of a seaplane may be considered as the sum of the length-beam ratios of the forebody and afterbody. The length-beam ratio of the forebody for a given gross-load coefficient C_{Δ_0} is the minimum required for satisfactory spray and seaworthiness characteristics at low water speeds and, for conventional airplane configurations, may be chosen on the basis of service experience with similar designs (reference 1).

The primary functions of the afterbody are to provide sufficient buoyant and dynamic lift at speeds up to the hump speed and an aerodynamic fairing for the main step in flight. At planing speeds the afterbody increases hydrodynamic resistance and decreases hydrodynamic stability. The afterbody length-beam ratio is therefore an important design parameter and has been the subject of much investigation in the towing tank, particularly in the development of specific seaplane designs.

This paper presents a correlation of the gross-load coefficient and afterbody length-beam ratio of 12 contemporary flying boats and amphibians. The airplanes chosen are representative of present seaplane design practice with regard to pointed afterbodies and therefore provide an empirical basis for choosing a suitable afterbody length-beam ratio, for preliminary design purposes, in the range commonly used. The correlation is broadly made in that the various performance parameters affected by the afterbody length or details of the afterbody shape are not considered. A choice of an afterbody length-beam ratio based on the results should, therefore, be checked by static water-line calculations and by towing-tank tests of the specific configuration being designed.

DATA

The flying-boat designations, loadings, and afterbody proportions are given in table I. The gross weights listed are representative design values or commonly used full-load values, although there is actually some variation in practice for different flight requirements. The afterbody proportions were collected from various sources including published three-view drawings, the records of the Langley Hydrodynamics Division, and the extensive compilation of reference 2. The afterbody lengths and sternpost angles tabulated are defined in figure 1. In the case of the PB2Y-3, Sunderland, and Shetland flying boats, which have steps of V plan form, the centroid of the step plan form is taken as the equivalent fore-and-aft position of the step as shown.

The gross-load coefficient C_{Δ_o} is defined as

$$C_{\Delta_o} = \frac{\Delta_o}{wb^3}$$

where

Δ_o gross load, pounds

w specific weight of sea water (64 lb/cu ft)

b maximum beam of hull, feet

CORRELATION AND DISCUSSION

The gross-load coefficients from table I are plotted against the corresponding afterbody length-beam ratios in figure 2. All of the points except those for the PB2Y-3 and S-44 flying boats lie approximately along a straight line through the origin, which indicates that a simple relationship exists in practice between the primary parameters considered.

The ratios of gross-load coefficient to afterbody length-beam ratio for the various airplanes are given in table I. If the PB2Y-3 and S-44 flying boats are excluded, these ratios have a mean value of 0.30 with an average deviation of 5 percent from the mean. This mean value, which corresponds to the mean line of figure 2, therefore becomes useful in the preliminary design of conventional hulls in the choice of afterbody length for hydrodynamic characteristics comparable with those of the airplanes considered.

The almost constant value of the ratio of the gross-load coefficient to the afterbody length-beam ratio for 10 of the airplanes is probably due largely to the static buoyancy requirements of the afterbody, since all the hulls were designed to trim nearly level at rest. The larger values for the other two airplanes are associated with higher load coefficients in relation to length-beam ratios than are commonly used. There is undoubtedly a large variation, among the airplanes listed, in the various hydrodynamic characteristics influenced by the afterbody.

The hulls with lower sternpost angles tend to have ratios of gross-load coefficient to afterbody length-beam ratio higher than the mean value, while the hulls with the higher sternpost angles tend to have lower ratios. This tendency indicates a possible effect, though small, of sternpost angle on the proper ratio.

CONCLUSION

Representative length-beam ratios of the afterbodies of most contemporary flying-boat designs are directly proportional to the gross-load coefficients.

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REFERENCES

1. Parkinson, John B.: Design Criterions for the Dimensions of the Forebody of a Long-Range Flying Boat. NACA ARR No. 3K08, 1943.

2. Locke, Fred W. S., Jr.: A Correlation of the Dimensions, Proportions, and Loadings of Existing Seaplane Floats and Flying-Boat Hulls. NACA ARR, March 1943.

TABLE I

LOADINGS AND PROPORTIONS OF POINTED AFTERBODIES

FOR VARIOUS FLYING BOATS

Flying boat	Operational gross weight Δ_o (lb)	Beam b (ft)	Afterbody length La (ft)	Sternpost angle (deg)	Gross-load coefficient C_{Δ_o}	Afterbody length-beam ratio La/b	$\frac{C_{\Delta_o}}{L_a/b}$
Consolidated Vultee PBY-5	30,000	10.21	15.46	8.5	0.44	1.51	0.291
Boeing B-314	86,000	12.50	26.46	7.2	.69	2.12	.326
Sikorsky S-43	17,800	7.50	16.00	9.2	.66	2.13	.310
Consolidated Vultee PB2Y-3	66,000	10.50	23.25	8.2	.89	2.21	.402
Short Empire	40,500	10.00	23.30	8.7	.63	2.33	.270
Sikorsky S-44	57,500	9.50	24.00	7.5	1.05	2.53	.415
Boeing XPBB-1	62,500	10.42	27.83	7.6	.86	2.67	.322
Martin PBM-3	50,000	10.00	27.40	8.5	.78	2.74	.285
Martin XPB2M-1	140,000	13.50	37.16	8.0	.89	2.75	.323
Martin JRM-1	145,000	13.50	41.87	7.8	.92	3.10	.297
Short Sunderland	52,000	9.50	31.00	8.3	.95	3.26	.292
Short Shetland	130,000	12.50	44.00	9.3	1.04	3.52	.295

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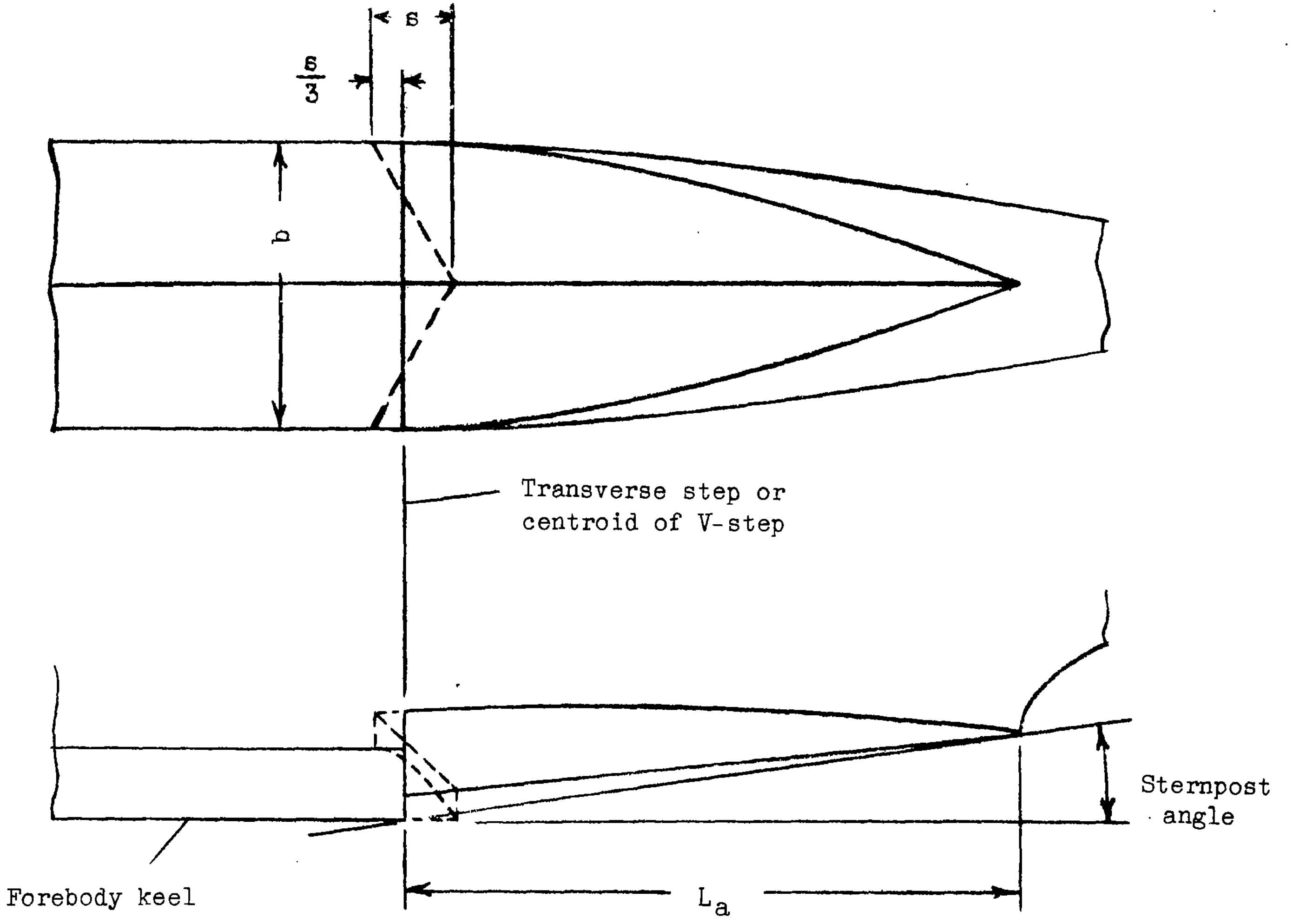

Figure 1.- Sketch defining dimensions used.

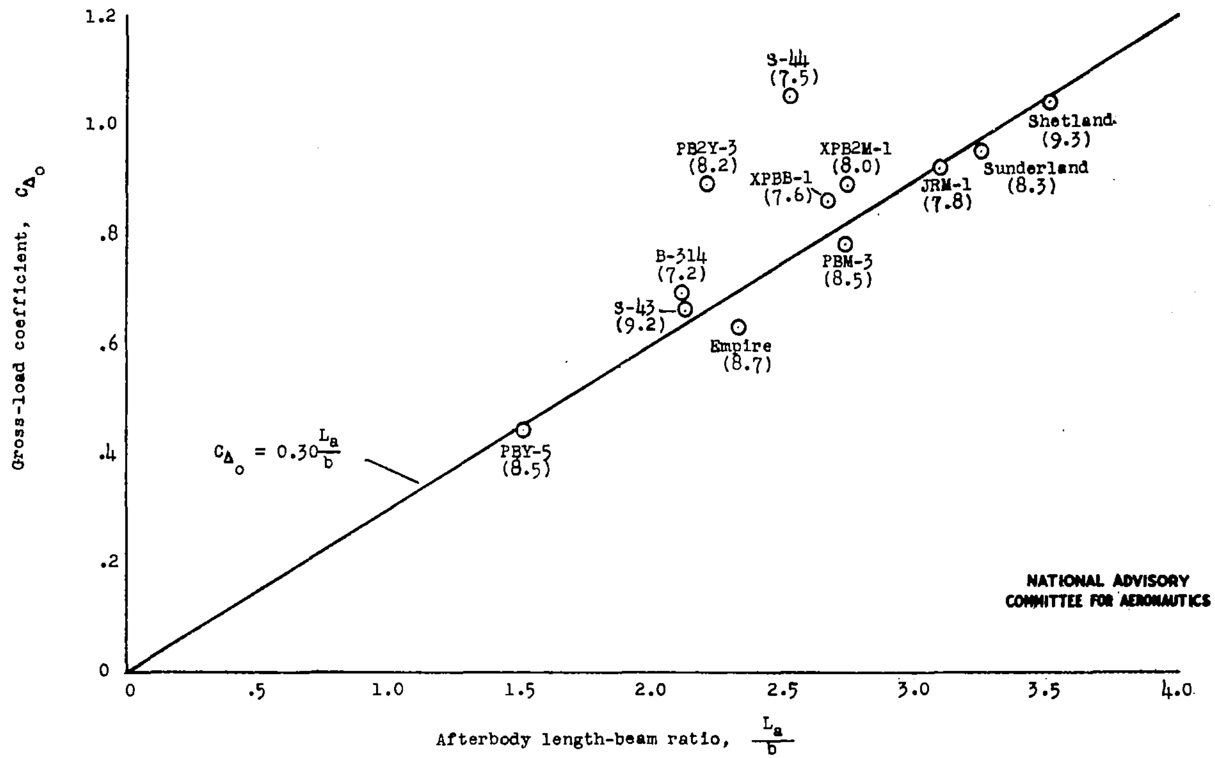

Figure 2.- Gross-load coefficient plotted against afterbody length-beam ratio for various flying boats. Numbers in parentheses are sternpost angles in degrees.